Rising to the Challenge

Celebrating the 25th Anniversary

of the Great Lakes Water Quality Agreement

Preface

April 15, 1997 marked the twenty-fifth anniversary of the signing, by Canada and the United States, of the Great Lakes Water Quality Agreement. This Agreement challenges the two countries to restore and enhance water quality in the Great Lakes system and provides the framework for binational cooperation. Its example and successes in responding to this challenge represent a significant achievement in international environmental affairs. This publication celebrates the efforts and accomplishments of individual citizens, scientists, private and public sector organizations and institutions which have made a difference and contributed to environmental progress in the Great Lakes basin.

The Great Lakes:
An Extraordinary Resource

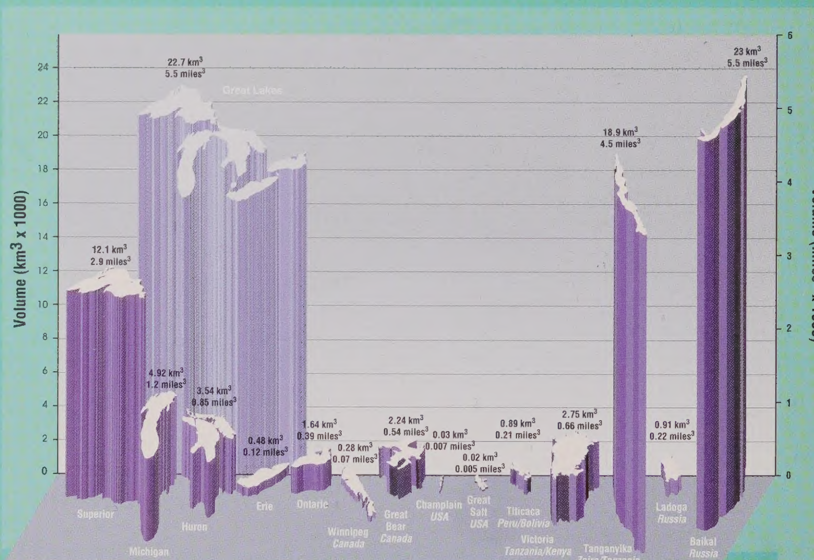
The Great Lakes constitute one of the largest freshwater systems on earth, containing 18% of the world's surface freshwater. Only the polar ice caps and Lake Baikal in Siberia contain more freshwater than the Great Lakes. Spanning more than 1,200 kilometres (745 miles) from west to east, these vast inland seas have played a major role in the ecology, climate, culture and economy of North America.

By all standards, the Great Lakes basin is rich in resources. Its waters have diverse and abundant fish communities, of which many species are used as a food source. Lands draining into the lakes support extensive coniferous, mixed-wood and deciduous forests, huge mineral and aggregate resources, abundant and diverse wildlife populations, and some of the most fertile agricultural areas in North America.

	Elevation m (ft)	Maximum Depth M (ft)	Volume km^3 (mi^3)	Water Area km^2 (mi^2)	Drainage Area km^2 (mi^2)	Retention Time years
Superior	183 (600)	406 (1332)	12 100 (2900)	82 100 (31700)	127 700 (49300)	191
Michigan	176 (577)	282 (925)	4 920 (1180)	57 800 (22300)	118 000 (45600)	99
Huron	176 (577)	229 (750)	3 540 (850)	59 600 (23000)	134 100 (51700)	22
Erie	173 (569)	64 (210)	484 (116)	25 700 (9910)	78 000 (30140)	2.6
Ontario	74 (243)	244 (802)	1 640 (393)	18 960 (7340)	64 030 (24720)	6

Source: The Great Lakes: An Environmental Atlas and Resource Book (Government of Canada and U.S. EPA 1995)

Over 24 million people rely directly on the Great Lakes as a source for drinking water. The lakes also provide water for transportation, power, recreation and a host of other uses. In times past, due to the immense size of the resource, inhabitants in the basin weren't concerned for the capacity of the lakes to absorb the by-products and wastes of a rapidly developing economy. Today, however, we know that the lakes are sensitive ecosystems vital to the health and quality of life of its citizens and vulnerable to the cumulative impacts arising from human activity.



(all lakes are drawn to 1:25,000,000 scale)

World Lakes

Settlement *and* Development

Native peoples were the first human inhabitants of the Great Lakes basin. At the time of European contact, around the year 1600, native peoples were principally hunters and gatherers and in transition to an agricultural society. Due to the relatively small populations, non-intensive cultivation technology, and the lack of grazing animals, these early inhabitants likely had no significant lasting effect on the regional landscape.

The first Europeans to enter the Great Lakes basin were explorers and missionaries. Étienne Brûlé, one of the scouts of the French explorer Samuel de Champlain, was the first to reach Georgian Bay in 1615. In 1634, Jean Nicollet reached Lake Michigan. Early exploration of the basin was driven primarily by natural resource exploitation. The first resources to interest the Europeans were fur-bearing animals, particularly beaver.

Fur exploitation was followed by timber exploitation. Commercial logging began in Upper Canada by the 1830s, and was followed shortly by operations in Michigan, Minnesota and Wisconsin. By 1861, over 60% of the upland forest had been removed in large portions of the basins of Lakes Ontario and Erie. Over 400 million board feet of timber, mostly white pine, was exported from southern Ontario between 1864 and 1866. In 1869, lumbering in the U.S. portion of the basin produced 3.6 billion board feet of timber. By 1879, this had jumped to 6.3 billion board feet and by 1889 it was about 10 billion board feet. By the turn of the century, however, production was already beginning to decline rapidly and the vast forests were replaced by farmland.

The Great Peshtigo Fire

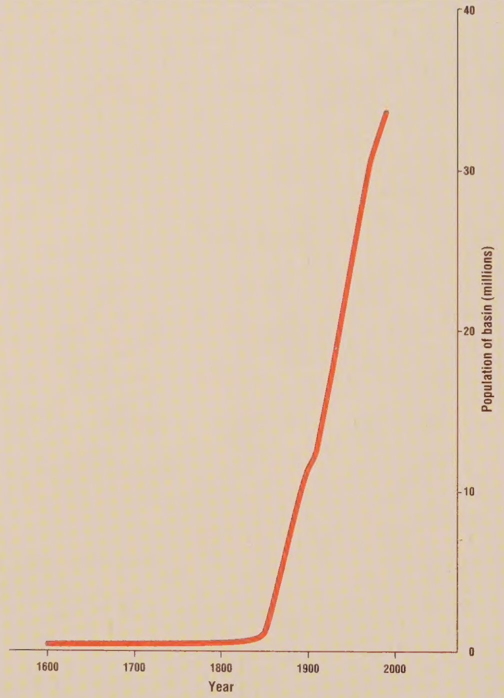
In addition to logging operations, wildfires contributed to deforestation in the Great Lakes basin. Peshtigo, Wisconsin, was a booming lumber town when a forest fire broke on October 8, 1871. The fire destroyed the town and more than 500,000 hectares (1.25 million acres) of forest. In terms of human life, it ranks as the costliest fire in U.S. history - more than 1,200 people perished.

Once the best farmlands were occupied, settlement expanded into marginal lands which were also rapidly deforested. With the impact of soil and wind erosion, basin jurisdictions began calling for reforestation as early as the 1860s.

From about 1880 through 1930, the economies of southern Ontario, New York, Ohio, southern Michigan, Illinois, and Indiana underwent a major shift from a rural-agrarian economy to North America's largest urban-industrial complex.

Steel mills, cement fabrication, automobiles, and textiles became the backbone of industrial centers such as Buffalo, Hamilton, Detroit, and Gary. Nowhere else in North America were conditions more ideal: abundant power sources, mineral and aggregate resources, superb water and land transportation systems, a large work force, and temperate climate. World War II extended production in these cities and spurred a tremendous appetite for fuels and chemicals. This, in turn, drove the formation of the petrochemical industry centered in Sarnia (Ontario), Niagara Falls (New York) and Midland (Michigan).

After the war, a combination of forces – including each farmer's drive to increase his productivity, new developments in the chemical industry as well as a variety of market forces – contributed to an increase in the manufacture and use of fertilizers and pesticides. At the same time, a growing demand for plastics and other synthetic products enhanced the growth of the organic chemicals and petrochemicals industries.



Population Growth in the Great Lakes Basin

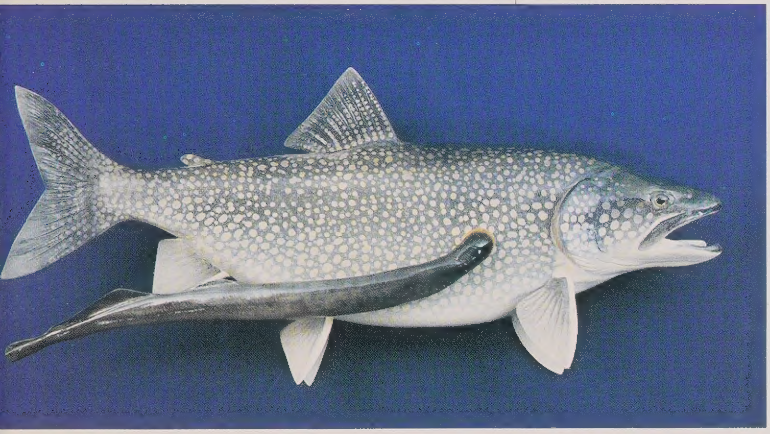
Environmental Consequences

While the Great Lakes basin as we know it today was shaped by glaciers over 9000 years ago, the most significant change occurred within a period of less than 200 years. Over a scant two centuries, the landscape of the basin was dramatically reconstructed by human activity... with substantial environmental impacts.

As early as the mid 19th century, serious public health issues began to appear in the major cities of the basin. In 1832, outbreaks of cholera in the newly founded Town of York (Toronto) were attributed to the contamination of drinking water by sewage and garbage. In 1854, Chicago experienced a cholera epidemic in which 5% of the population died. In 1891, the basin's death rate from typhoid reached 124 per 100,000. This prompted Chicago to reverse the flow of the Chicago River to carry sewage away from Lake Michigan. Due to harbor contamination, the city of Hamilton installed a steam-powered water pump to draw water from deep in Lake Ontario in the early 1870s.

By the middle of the 20th century, lake-wide pollution problems in the form of excessive algae and aquatic weed growth were evident. Nutrient enrichment, primarily due to phosphates in fertilizers and municipal and industrial wastewater, overloaded the assimilative capacity of many harbors and bays as well as the central and western basins of Lake Erie. By the late 1960s, degradation had become so extreme that newspaper headlines such as "Lake Erie is Dead" were common.

The lucrative commercial fishing industry was affected by nutrient enrichment as well as over-fishing, habitat destruction, and the introduction of exotic species such as smelt, alewife and sea lamprey. With the opening of the Erie and Welland Canals (1825 and 1829, respectively) and the St. Lawrence Seaway (1959), the expansion of navigation and shipping in the Great Lakes allowed or contributed to the invasion of a number of exotic species. Indeed, since 1810 a total of 139 species of plants, fish, algae and mollusks are known to have been introduced to the Great Lakes ecosystem.



Widespread contamination of the Great Lakes by persistent toxic substances such as DDT and DDE, mercury, and PCBs was being documented in the 1960s. The impact of toxic chemicals was first observed in the form of reproductive problems in native wildlife. Populations of cormorants, Herring Gulls, Bald Eagles and Ospreys declined dramatically. Birth defects – for example, crossed-bills, club feet, and skeletal deformities – were also observed in several types of waterbirds. The common thread? All these species relied on Great Lakes fish as a major food source.

Soon after, the link to humans and the potential for human health effects became evident. In 1971, as a result of finding PCB residues in fish, Michigan issued the first public fish advisory for the Great Lakes limiting the consumption of lake trout and salmon from Lake Michigan.

The **Growth** *of* Environment Consciousness

Eroded fields and "wrecked forests" in Sand County, Wisconsin, led Aldo Leopold to describe eloquently how an ecosystem works and to declare the need for an environmental conscience. In 1949, he stated that environmental laws and regulations would not be sufficient on their own; each and every citizen must develop anguish and disgust for environmental degradation.

The publication of *Silent Spring* in 1962 by Rachel Carson triggered public anxiety over the potential effects of chemicals, particularly pesticides, on nature, and ultimately on humans.

"I truly believe that we in this generation must come to terms with nature, and I think we are challenged as mankind has never been challenged before, to prove our maturity and mastery, not of nature, but of ourselves."

A true public environmental conscience was forming. It was soon built into a populist movement supported by scientific and academic communities. Textbooks and environmental sciences began to focus on ecology as a discipline and explore the impacts of human activities.

This new environmental conscience grew quickly and became institutionalized in government with the formation of environmental councils, ministries, departments, and agencies in many western nations. The U.S. Environmental Protection Agency (U.S.EPA) and Canada's Department of the Environment (Environment Canada) were both formally established in 1970. The creation or expansion of sophisticated research institutions soon followed.

In the Great Lakes basin, a symbol of this new environmental conscience was the signing of the Great Lakes Water Quality Agreement (GLWQA) in 1972 by the Governments of Canada and the United States.

Significant Milestones Leading To The GLWQA

1894/95-

International Irrigation Congresses held in U.S with resolutions to appoint "an international commission to act....adjudicating the conflicting rights which have arisen, or may hereafter arise, on streams of an international character."

1905 -

International Waterways Commission created to advise governments on levels and flows in Great Lakes (operated 1905 to 1913)

1909 -

signing of Boundary Waters Treaty establishing International Joint Commission with authority to resolve disputes over use of water resources that cross the international boundary

1912 -

first IJC Reference on Great Lakes - report on Pollution of Boundary Waters

1946 -

Reference report relating to Pollution of Great Lakes Connecting Channels (St. Clair River, Lake St. Clair, Detroit River and St. Marys River)

1948 -

Reference report on Pollution of Niagara River

1951 -

IJC concedes that "although the matter of industrial waste was of little or no concern in 1913, it is today a major problem"

1954 -

United States and Canada sign Convention on Great Lakes Fisheries for the control of the sea lamprey and conservation of fish stocks

1964 -

IJC began new Reference Study on Pollution in the Lower Great Lakes

1970 -

Lower Lakes Reference identified eutrophication due to excessive phosphorus

1971 -

IJC given Reference to study pollution in the waters of the Upper Great Lakes (Huron, Michigan and Superior)

1972 -

Reference Study on Pollution of Great Lakes from Land Use Activities (PLUARG) initiated

The Boundary Waters Treaty of 1909 between Canada and the United States set out the principles and procedures under which waters along the border

The **Agreement**

were to be managed. It established the International Joint Commission (IJC) consisting of six members, three from each country. The IJC authorizes the uses, diversions or obstruction of boundary waters and transboundary streams, and conducts investigations at the request of the Governments.

The treaty concentrated on water levels, flows and uses but did recognize the importance of water quality . *"It is further agreed,"* the treaty specified, *"that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other."*

The first study of water pollution in the Great Lakes was commissioned by the IJC in 1912. The conclusion, released in 1918, was that the water quality situation in parts of the lakes was *"generally chaotic, everywhere perilous and in some cases disgraceful."*

The IJC's 1964 reference investigation on pollution in the lower Great Lakes (Lakes Ontario and Erie) indicated that nutrient enrichment (eutrophication), particularly related to discharges of phosphorus, was causing massive growths of algae resulting in fish kills, degradation of beaches and clogging of water intakes. The results of these studies were used to develop specific programs and measures which would form the basis for the first GLWQA.

On April 15, 1972, 63 years after the signing of the Boundary Waters Treaty, Prime Minister Trudeau and President Nixon gave formal recognition of water quality as a major transboundary management issue in the signing of the GLWQA.

The 1972 GLWQA established the commitment to restore and enhance water quality in the Great Lakes system. Objectives were specified that would reduce nuisance conditions (e.g. colour, odour, floating oil and scums, aquatic weeds and algae) and the discharge of substances toxic to human, animal or aquatic life. In addition, specific numerical targets were included in the Agreement for the reduction of loadings of phosphorus to Lakes Erie and Ontario.

Agreement Between The United States Of America And Canada On Great Lakes Water Quality

The Government of the United States of America and the Government of Canada, Determined to restore and enhance water quality in the Great Lakes System; Seriously concerned about the grave deterioration of water quality on each side of the boundary to an extent that is causing injury to health and property on the other side, as described in the 1970 report of the International Joint Commission on Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River; Intent upon preventing further pollution of the Great Lakes System owing to continuing population growth, resource development and increasing use of water; Reaffirming in a spirit of friendship and cooperation the rights and obligations of both countries under the Boundary Waters Treaty signed on January 11, 1909, and in particular their obligation not to pollute boundary waters; Recognizing the rights of each country in the use of its Great Lakes waters; Satisfied that the 1970 report of the International Joint Commission provides a sound basis for new and more effective cooperative actions to restore and enhance water quality in the Great Lakes System; Convinced that the best means to achieve improved water quality in the Great Lakes System is through the adoption of common objectives, the development and implementation of cooperative programs and other measures, and the assignment of special responsibilities and functions to the International Joint Commission; Have agreed as follows: ....

Preamble to the Great Lakes Water Quality Agreement of 1972

Research and surveillance capabilities within the basin increased rapidly following the implementation of the 1972 Agreement. The eutrophication issue was more critically defined and many other water quality problems, particularly those relating to toxic chemicals, were documented.

Increased information and scientific understanding of the lakes led to new and more refined environmental management objectives and targets. These were incorporated into a revised GLWQA, signed on November 22, 1978. This Agreement extended the concern for persistent toxic substances by establishing the policy that their discharge be *virtually eliminated* and the philosophy for control would be *zero discharge*. As well, refined phosphorus target loadings for the lower Great Lakes were specified and, for the first time, target loadings for the upper lakes were identified.

The 1978 GLWQA is unique for its inclusion of the ecosystem concept. The Great Lakes Basin Ecosystem is defined in the Agreement as *"the interacting components of air, land, water, and living organisms, including man, within the drainage basin ...."*

The ecosystem perspective broadens the understanding of how humans and the environment interact. It provides both a philosophical framework and a scientific rationale for the notion that "everything in the basin is related to and affects, to some degree, everything else in the basin". It recognizes that no one factor was responsible for systemic ecological decline in the region, and that existing problems cannot be addressed within strict jurisdictional, geographic or disciplinary boundaries.

The 1978 Agreement was amended by Protocol to incorporate new concepts of ecosystem-based management in November 1987. These amendments called for greater coordination among various jurisdictions in developing remedial measures through the use of *Remedial Action Plans* for the most polluted areas of the lakes *(Areas of Concern)* and through *Lakewide Management Plans.*

The ecosystem approach was reflected in the amended Agreement's direction to investigate all pollutant pathways including the atmosphere, groundwater, sediments, and surface runoff, and to develop remedial measures for all sources including industrial and municipal dischargers (point sources) as well as agricultural, forestry and urban practices (non-point sources).

Measuring

The attention and considerable resources invested in the Great Lakes have produced significant dividends: the growth of scientific institutions and knowledge, public involvement, pollutant reductions and, most importantly, improvements in environmental quality.

Science: Response to Need

Science forms the basis for our understanding of ecological processes, the analysis of environmental problems, and the development of management and remedial solutions. While a large complex freshwater ecosystem such as the Great Lakes presents a formidable challenge to the scientific community, it has responded with a spirit conducive to innovative thought and analysis.

The GLWQA served as a catalyst, which allowed science and research to flourish. In the 1970s and 1980s, government research institutions, such as the Canada Centre for Inland Waters and the Great Lakes Environmental Research Laboratory of the National Oceanic and Atmospheric Administration (NOAA), were forming and rapidly expanding. Universities and colleges in the basin were also expanding their environmental research capabilities.

The first Great Lakes Research Conference was held in 1953 at the Great Lakes Research Institute at the University of Michigan. This became an annual event which led directly to the formation, in 1962, of the International Association for Great Lakes Research (IAGLR). In 1975, the annual conference proceedings evolved into the Journal of Great Lakes Research which soon became the pre-eminent scientific journal on large lakes research.

Progress

The first Great Lakes conferences were held at the University of Michigan and the University of Toronto which, with the support of the then Ontario Department of Lands and Forests, developed a Great Lakes research program in 1959. Since 1962, the conference has alternated annually between Canada and the United States and is hosted by wide variety of universities.

With the initiation of several large-scale, cooperative research efforts, the early 1970s marked the beginning of what has been referred to as "the modern era" of Great Lakes research. The rapid growth and development of research was hastened by the fact that the problems in the Great Lakes basin required an inter-disciplinary, multi-institutional approach.

Intensive Surveys In The Great Lakes Basin

Project Hypo - Lake Erie eutrophication (1970)

IJC Reference on Pollution of the Upper Great Lakes (1972-1977)

Lake Ontario International Field Year for the Great Lakes (IFYGL) (1972-1973)

IJC Reference on Pollution from Land Use Activities Group (PLUARG) (1972-1979)

Lake Erie Binational Survey (1979 - 1980)

Niagara River Toxics Study (1981 - 1984)

Upper Great Lakes Connecting Channels Study (St. Clair, St Marys, Detroit Rivers and Lake St. Clair) (1984-1988)

Green Bay Mass Balance Study (1989 - 1995)

Saginaw Bay Ecosystem Study: Impact of Zebra Mussels (1989-1996)

Lake Michigan Mass Balance Study (1994-ongoing)

Since research on large, complex lake ecosystems requires a very high level of technological sophistication, many specialized sampling tools and state-of-the-art analytical equipment have been developed. A fleet of research vessels dedicated to sampling in the lakes – for example, Canada's *Limnos*, U.S.EPA's *Lake Guardian*, NOAA's *Shenehon*, and Ontario's *Guardian II* – has been particularly valuable to research and monitoring.

Great Lakes' scientists and institutions have developed an international reputation for landmark studies on complex large lake ecosystems. These have involved a wide range of scientific endeavor in the fields of nutrient dynamics and eutrophication, pathways and effects of toxic substances, atmospheric transport, hydrodynamic modeling, fish and wildlife population dynamics, and many others.

Public Involvement: Partners in Progress

A concerned, knowledgeable and involved citizenry plays a key role in environmental affairs within the Great Lakes basin. In 1972, there were virtually no public interest groups dedicated primarily to Great Lakes issues. However, there were several significant environmental special interest groups, such as the Federation of Ontario Naturalists and the Lake Michigan Federation, which had interests that included improving Great Lakes water quality. These groups generally had large constituencies which in time expanded and spun-off into new special interest groups.

In the 1980s, with the advent of an era of popular environmentalism in Canada and the United States, a rapid expansion occurred in the number and size of public interest groups. This was also the decade in which public education on environmental issues became entrenched in private and government organizations as a key component of all outreach programs.

Great Lakes Tomorrow was the first public interest group focusing principally on Great Lakes issues. Formed in the mid-1970s as a binational watchdog organization, it was modeled after the successful Lake Michigan Federation. Its primary contribution has been in the field of public education.

In 1982, Great Lakes United was formed in response to an initiative by the Michigan United Conservation Clubs. 'GLU' has become one of the foremost and most influential of the basin-wide public interest groups. Its newsletter *"The Great Lakes United"* has been particularly successful. With its large binational constituency, it also acts as a significant lobby group to federal, state, and provincial governments.

Today there are numerous special interest groups focusing on the Great Lakes and likely hundreds of "grass roots" organizations working at the community level. Local groups typically become involved in projects which involve environmental education, saving a wetland or an environmentally sensitive area, rehabilitating a stream, and monitoring environmental change or pollution events. These volunteer stewardship groups play a critical role for a much larger Great Lakes constituency.

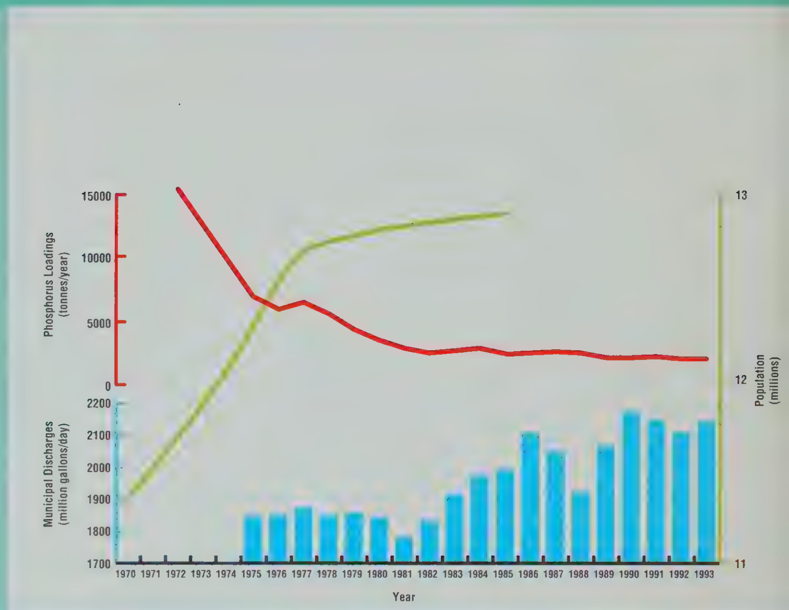
Public consultation and involvement have been critical to the delivery of programs and activities arising from the GLWQA. Foremost among these is citizen participation in the development of *Remedial Action Plans* (RAPs) for 43 designated *Areas of Concern* around the Great Lakes. Relevant interests or stakeholders are brought together to achieve consensus on issues and remedial actions in long-standing problem locations where GLWQA objectives are not being met. They become better informed and more aware of the extent of the problems and often become leading proponents of community action.

Reducing Pollution

Pollution abatement initiatives undertaken in Canada and the United States within the Great Lakes basin have achieved many important successes. In contrast to 1972, for example:

- occurrences and magnitudes of chemical spills to the lakes have been reduced significantly;
- physical pollution in the form of "objectionable" and "nuisance" materials forming scums, sludges and odours, have almost been eliminated;
- significant reductions in industrial pollution have been achieved;
- phosphorus inputs have been controlled to the point that algal growth has been slowed and water clarity in Lakes Erie and Ontario improved; and
- several contaminants such as PCBs, DDT, and mercury have declined in fish and wildlife by as much as 90%.

The following profiles highlight some of the successes achieved through binational efforts.



Comparison of phosphorus loadings with total municipal discharges, Lake Erie (includes contribution from Detroit River). The population trend of the Lake Erie basin is also provided.

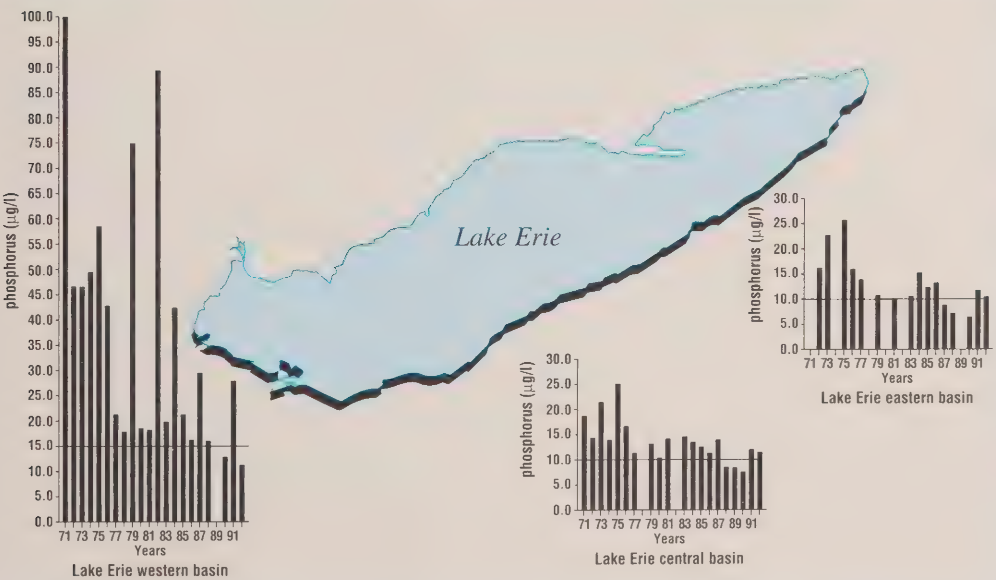
" Lake Erie Revived "

The excessive addition of nutrients to Lake Erie due to human activity accelerated the eutrophication or natural aging process of the lake. Within a single generation, users of the lake had noticed increasing weed growth in shallow bays, massive algal material washed up onto popular swimming beaches, change in colour and loss of clarity within the lake, taste and odour problems in drinking water, and declining fish populations. As well, scientists documented depressed oxygen levels in the lake's bottom waters.

In response, the Governments of Canada and the United States asked the IJC to undertake a major investigation into the nature, extent, effects, and causes of eutrophication in the lower lakes. The results, released in 1970, led to an unprecedented international plan of action to stop further degradation and begin restoration. The commitments by governments were embodied in the 1972 GLWQA.

Phosphorus was identified as the key nutrient controlling the eutrophication process; inputs to the lake were attributed to municipal wastewater containing household laundry detergents, industrial wastes and agricultural runoff. These sources were targeted for action and phosphorus load reductions were specified in the 1972 GLWQA. Subsequent actions which were implemented included the expenditure of over $7.6 billion by Canada and the United States to construct and upgrade municipal treatment plants in the basin; the limitation of phosphorus in household laundry detergents; and the adoption of conservation tillage and better fertilizer management practices by farmers.

Loadings of municipal phosphorus to Lakes Erie and Ontario have been reduced by almost 80%. Reductions in the amount of algae have been noted and the areal extent of oxygen depletion in the bottom waters of Lake Erie has been decreasing since the early 1970s. The phosphorus control plan and the subsequent improvements in a lake which had been declared "dead" represent a major achievement for binational cooperation.



Lake Erie open water phosphorus concentrations (µg/l). Horizontal lines at 15.0 and 10.0 µg/l represent proposed guidelines.

" Pulp, Paper and Effluent "

Forest harvesting for pulp and the production of paper products is one of the largest, oldest and most ubiquitous of industries within the Great Lakes basin. For many small towns in the northern, forested portions of the basin, it is the sole economic base. In 1995, seventy-two pulp and paper mills discharged effluent directly into receiving waters in the basin. Mills are located in Ontario (18), Michigan (20), Wisconsin (20), New York (12), and Ohio (2).

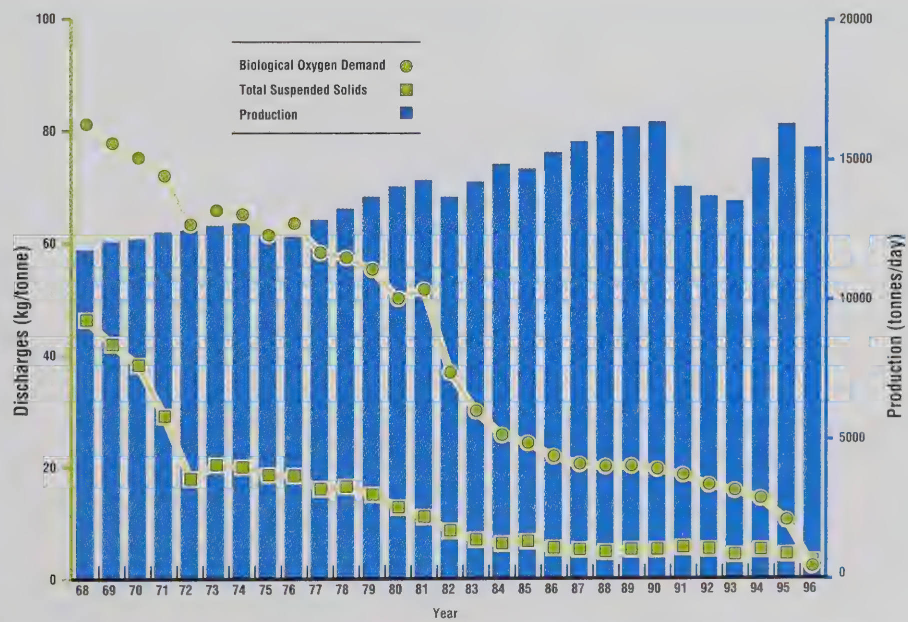
Each metric ton (1,102 tons) of paper requires, on average, 100 cubic metres (26,000 U.S. gallons) of water in the production process. Clearly, these large quantities result in large volumes of wastewater discharged to nearby lakes and streams. This waste typically carried large quantities of wood fiber, finely divided solids, and a complex mixture of compounds derived from wood and chemicals used in the production process. In addition, organochlorine contaminants, including some dioxins and furans, have been associated with wastewater from Kraft mills which use chlorinated compounds as bleaching agents to whiten the final paper products.

Historically, pollution abatement focused on conventional pollutants, such as total suspended solids (TSS) and oxygen-consuming materials as measured by biochemical oxygen demand or BOD. The production of pulp results in considerable quantities of suspended solids and high BOD waste streams which deplete dissolved oxygen in receiving waters and ultimately harm benthic organisms and fish if not adequately treated.

With the installation of secondary treatment facilities during the early 1980s to treat mill effluent, TSS and BOD loadings declined dramatically. Today, total average BOD loadings are only about one-eighth of their loadings in the late 1960s despite increasing production of paper products.

The use of chlorine dioxide in place of elemental chlorine in the bleaching process is perhaps the most well established mechanism to reduce the quantity of chlorinated organics in mill effluent. Concentrations of dioxins, furans, and AOX (adsorbable organic halogens, a surrogate parameter which was defined for monitoring and regulation of the hazard presented by effluent mixtures) have decreased by 90% or more since the late 1980s.

Mills which do not discharge any effluent are the way of the future for the pulp and paper industry. One technology being examined is the closed-cycle mill (Effluent Free Mill) in which all effluent is recycled within the mill. Significant progress is being made for this and other reduced-effluent technologies.



Annual production and direct discharges of Ontario pulp and paper mills, 1968-1996. Great Lakes mills account for between one and two thirds of these totals over this period.

" Why So Many Cormorants? "

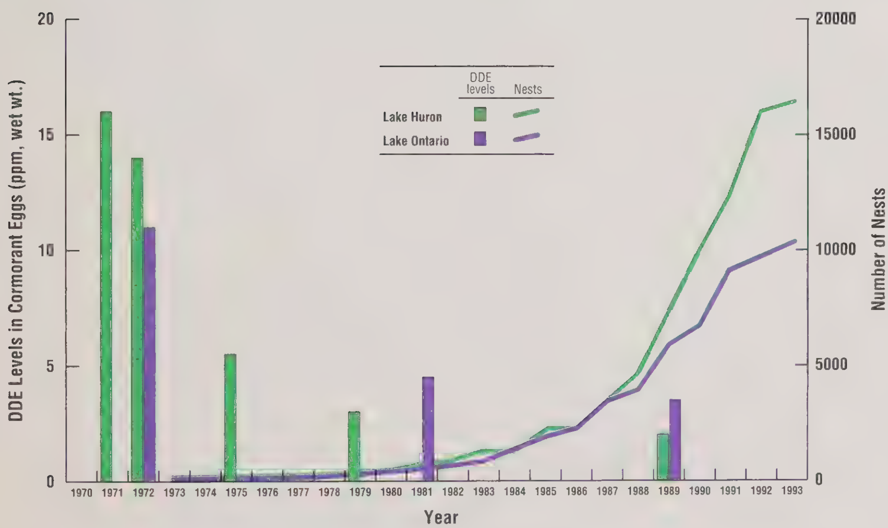
The Double-crested Cormorant, a large fish-eating bird found throughout the Great Lakes, has undergone dramatic changes in population over the past three decades. Devastated by the effects of toxic chemicals, the number of nesting pairs decreased by 86% between the 1950s and the 1970s. Today, however, the cormorant is more numerous on the Great Lakes than at any time in its recorded history.

During the 1960s, scientists found that the eggshells of nesting cormorants had been thinning since about 1955. By the early 1970s, eggshells were about 30% thinner than normal. The eggshells could not withstand the weight of the incubating bird and would break before reaching term. This had a devastating impact on reproduction. Population declines were attributed to the high levels of persistent toxic substances, particularly DDE (a breakdown product of the pesticide DDT) and PCBs, then present in the Great Lakes. Such contaminants bioaccumulate in the aquatic foodchain reaching higher levels in fish. Fish-eating birds such as the cormorant consume thousands of fish over a lifetime, thereby accumulating high levels of chemicals in their bodies. Indeed, residues of DDE and PCBs found in the cormorant eggs in the Great Lakes basin were exceptionally high.

Reduced productivity and eggshell thinning were the first problems related to contaminants identified in birds on the Great Lakes. Eggshell thinning is strongly correlated with the presence of DDE which inhibits the enzyme needed to mobilize calcium for eggshell formation in the female bird.

In the mid 1970s, cormorant numbers began a dramatic recovery. From 1973 to 1991, their numbers increased more than 300 times – a doubling every three years. Corresponding to this increase in population has been an increase in eggshell thickness to more normal levels. The incidence of deformities such as crossed-bills was also decreasing in some areas. At the same time, contaminant levels were falling. The most regularly monitored sites showed DDE and PCB levels in cormorant eggs decreasing by more than 80% between 1971 and 1989. Similar reductions have been recorded in several other species of Great Lakes fish and wildlife including Herring Gulls, Common and Caspian Terns, Ospreys and Lake Trout.

The return of a species that had almost vanished from the Great Lakes has been a tremendous success story. Through legislated controls on the production and use of DDT and other persistent toxic chemicals, levels of these substances have declined dramatically in the Great Lakes and allowed the cormorant population to again breed successfully. There are also other encouraging signs of improving ecosystem health. Since the mid-1970s, Osprey populations in the upper lakes have grown steadily with average annual rates of population increase from 7% to 15%. The Bald Eagle is being re-introduced to the Lake Erie basin and Lake Trout are now self-sustaining in areas of Lake Superior thus eliminating or substantially reducing stocking programs by jurisdictions around this lake.



Levels of DDE in cormorant eggs compared with cormorant populations in Lakes Ontario and Huron.

" Contaminated Sediments –Dealing with the Residue of the Past "

The legacy of pollution abuses can be measured in the historical record of sediment contamination in the Great Lakes depositional basins. Persistent contaminants from industrial and municipal facilities and other landuse practices are often associated with solids which settle in estuaries, harbors and the deep basins. Through physical, chemical and biological processes, these contaminants can continue to circulate and exert their impacts.

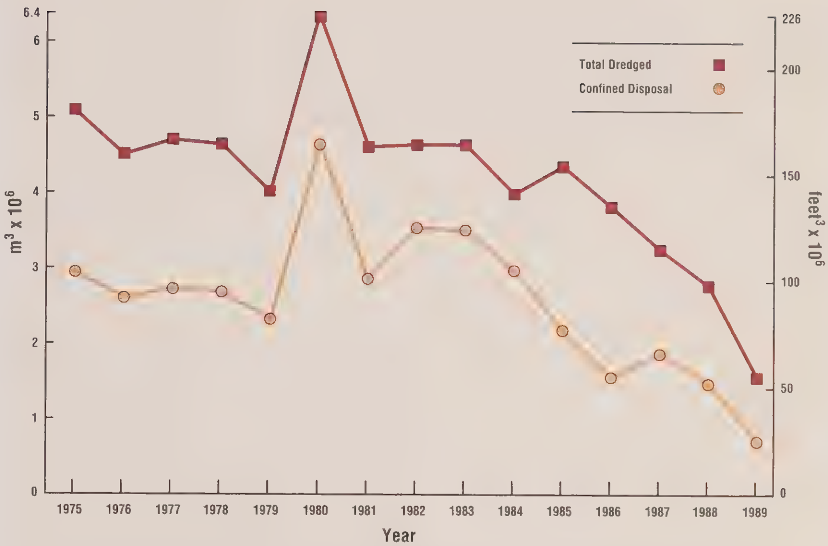
Extensive dredging is carried out in the Great Lakes to maintain navigation depths for shipping. Typically the material dredged from harbors and inshore areas was deposited in the open waters of the lakes. Very little consideration was given to the quality of material being dredged and no special efforts were made to control the dispersal of such material either during the dredging or disposal operations. However, by the late 1960s, there was mounting concern over the increasing pollution of the Great Lakes from all sources and the possibility of irreversible harm being done.

The 1972 GLWQA recognized the need to understand better the role of dredging in creating or aggravating environmental problems. It specified that Canada and the United States undertake a review of existing practices, programs, laws and regulations. The objectives were to develop compatible criteria for the characterization of polluted dredged material and to recommend compatible programs governing the disposal of dredged material in open water.

Since 1972, jurisdictions in the Great Lakes basin have devoted considerable effort to research sediment/contaminant/biota interactions, establish criteria for designating polluted sediment, undertake detailed sediment contaminant surveys, and develop more appropriate dredging technology and disposal options. Massive quantities of dredged material have been disposed in confined disposal facilities to isolate contaminants and prevent their continuing cycling within the Great Lakes system.

Of the 42 remaining designated *Areas of Concern* (Collingwood Harbour was delisted as such an area in 1994), all have varying degrees of sediment contamination. Remediation has involved the development of various sediment management strategies. One of these areas, Waukegan's Old North Harbor, celebrated a major milestone on February 20, 1997, with the removal of signs warning anglers not to eat fish caught in the harbor because of possible contamination from PCBs. Removal of the signs marked the end of two decades of fish consumption restrictions in the harbor.

The sediment contamination problem in Waukegan was discovered in 1976. The source of the PCBs was the leakage of hydraulic fluids from a manufacturing plant into a ditch which drained into the harbor. The leakage began in the early 1960s and continued for about a decade, contaminating sediments within the harbor. Due to the bioaccumulation of PCBs within the local food chain, most fish within the harbor had levels of PCBs exceeding 5 ppm. Some had concentrations as high as 30 ppm. Signs were placed warning the public not to consume fish taken from the harbor. In fact, contamination was not limited to the harbor and contributed to the overall Lake Michigan PCB problem.



Total of material dredged (in terms of placed volume) in the Great Lakes basin, 1975 to 1989, including portion placed into confined disposal facilities. Note: confined disposal data for 1975-79 has been derived from a five-year average percentage of total.

In response, a Citizens Advisory Group was formed and a Remedial Action Plan (RAP) was developed to restore the harbor to full attainment of all uses. In 1982, the Waukegan site was placed on the first National Priorities List for Superfund. The PCB remedy construction was completed in 1994/95 at a cost of $24 million (U.S.). Over a million pounds (>450,000 kg) of PCB contaminated sediments were dredged from the harbor. PCB concentrations in fish from this harbor are now comparable to those found in fish from other harbors along the Illinois shoreline of Lake Michigan.

A number of remedial projects on contaminated sediment are completed, underway or planned in the Great Lakes *Areas of Concern*. As the efforts in Waukegan Harbor demonstrate, there are direct environmental benefits resulting from the cleanup of highly contaminated sediments.

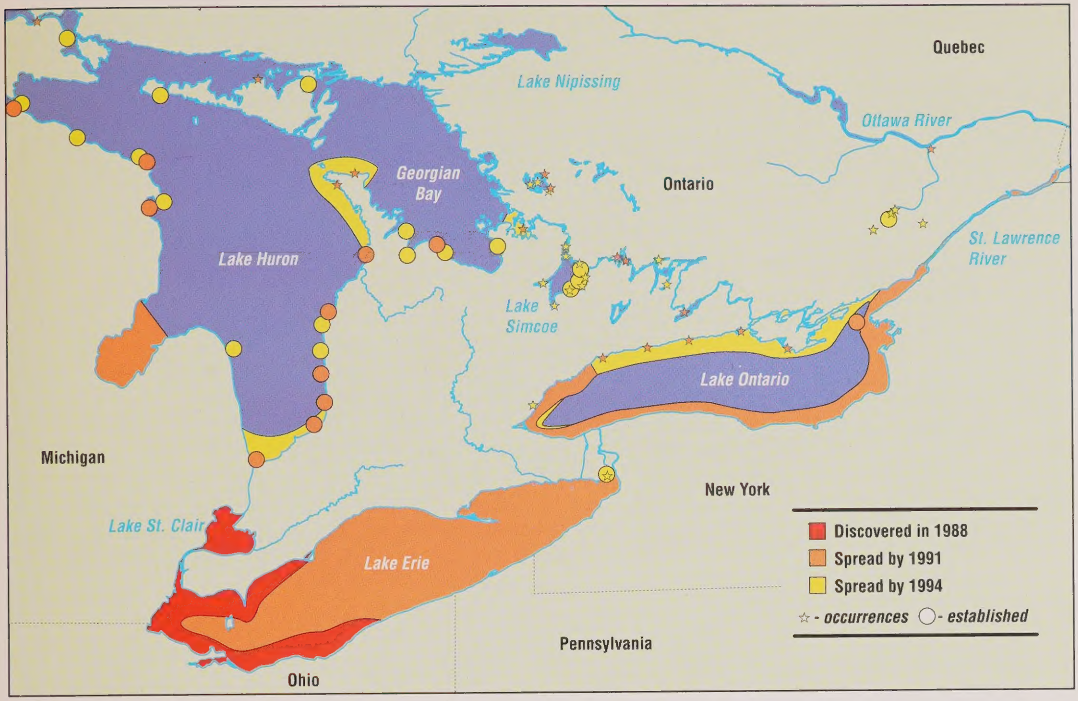
Into the New Millennium

In the 25 years since the signing of the GLWQA much has been accomplished. Our science and institutions have been strengthened and this has paid dividends in our ability to diagnose environmental conditions in the lakes. Various levels of government, municipalities and industries joined in massive cleanup initiatives and major investments in pollution abatement. Citizens in the basin, have a heightened awareness and knowledge of environmental matters; many volunteer in community based environmental initiatives.

During this 25 year period there have been environmental successes - reductions in the discharge of nutrients, persistent toxic substances and other contaminants; declining levels of persistent toxic substances in the tissues of fish and wildlife; enhancements in water quality; and improvements in ecosystem health as measured in the populations of sentinel species such as the Bald Eagle, Osprey and Lake Trout.

Despite these successes, however, the Great Lakes still face formidable challenges. For example -

- Levels of persistent toxic substances remain unacceptably high in a number of cases. Also worrisome is scientific evidence on the impact of these substances on endocrine function in fish and wildlife species. *The Great Lakes Binational Toxics Reduction Strategy: Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes,* signed by the U.S.EPA and Environment Canada on April 7, 1997, renews, expands and challenges the efforts of the two countries to seek further reductions in a number of problematic contaminants.
- The long-range atmospheric transport of contaminants leaves the Great Lakes vulnerable to the deposition of substances from the air from sources both within the basin and from far outside the basin. For example, 72 to 96% of the total annual loading of benzo(a)pyrene, a common polycyclic aromatic hydrocarbon (a class of substances produced in combustion processes), to Lakes Superior, Michigan, and Huron is attributed to atmospheric deposition. Enhancements in international monitoring networks and emission inventories and domestic abatement measures are being pursued to address this issue. In addition,the United States and Canada are taking Great Lakes contaminant priorities into international negotiations to seek further curbs on the release of such substances by other countries.



Spread of the zebra mussel in the lower Great Lakes.

- Exotic species continue to be unintentionally introduced into the Great Lakes with severe impacts on indigenous species. The zebra mussel is a relatively recent invasive species which is now having a significant impact on the ecology of Lake Erie. Significant success has been achieved in the notable case of the sea lamprey program under the auspices of the Great Lakes Fishery Commission. Sea lamprey populations in most of the lakes have been reduced by 90% from their historic high of the 1940s and 1950s. However, it remains a continuing challenge to maintain such control, tackle other exotic species and ensure no further introductions occur.

- Expanding populations and changes in landuse due to urbanization and other development processes continue to impact sensitive tributary and nearshore habitats. These areas are often critical for the maintenance of Great Lakes water quality and the protection of many fish and wildlife species. There are often conflicting demands placed on these waters and choosing environmentally sensitive development options remains a substantial challenge.

The past 25 years have shown that the Great Lakes community can rise to challenges. International commitments have been made and substantial resources allocated. Progress has been achieved. Thousands of citizens in the United States and Canada, representatives of industry, labour, government, environmental organizations and other sectors have been inspired to take action and much is possible. Where there is a will and energy and a common vision...the restoration and enhancement of water quality in the Great Lakes System...there is clearly a way.

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Websites

Great Lakes Information Network (GLIN)
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Great Lakes Information Management Resource (GLIMR)
URL http://www.cciw.ca/glimr/intro.html

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Figures

World Lakes -
data from the International Lake Environment Committee Foundation (February 1997) and the National Geographic Atlas of the World (6th edition, 1995) *Pg. 2*

Population Growth in the Great Lakes Basin -
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Lake Erie Phosphorus Loadings -
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Lake Erie Phosphorus Concentrations -
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Ontario Pulp and Paper Mills -
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Spread of Zebra Mussels in the lower Great Lakes -
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Midland (Ontario) logging circa 1901; Archives of Ontario *Pg. 3*

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Double-crested Cormorants (Note cross-bill defect);
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GREAT LAKES WATER QUALITY AGREEMENT

Twenty-fifth Anniversary

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